Art. XII.—*The Calculimetre.*

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The Calculimetre is a circular measure of French make for performing approximate arithmetical and trigonometrical calculations. It consists of a flat disc of metal about the size of a watch, which can easily be attached to a chain and carried in a watch pocket. On one face, there are the two principal scales—one movable, the other fixed—for performing the ordinary rules of multiplication, division, and proportion; also a third scale for finding the squares and square roots of numbers. On the reverse face may be instantly found, by means of a movable arm, the logarithms of numbers, and the sines and tangents (the latter being under 45°) of angles.

This instrument is, of course, based on the principle of Gunter's line, *i.e.*, a scale divided logarithmetically, but marked with the natural numbers only, and has the advantage over the ordinary carpenter's and other similar slide-rules of convenience and portability, and a readier application to arithmetical calculations, besides having the additional scales for trigonometrical calculations. The arithmetical scales are about the same length as in the ordinary slide-rule, and, with good observation, results with the first three figures of a result can often be closely ascertained.

Some time ago, I brought before the notice of this Society, *Fuller's Calculating Slide-rule,** which will readily give accurate results to the fourth and sometimes to the fifth figure. In that ingenious instrument, however, the scale is of great length, being no less than 41½ feet, it being drawn in a spiral form round a cylinder; whilst in the more portable calculimetre the scale is only 6¼ inches in length, and of course cannot give the more extended results which may be obtained with the invaluable rule of Professor Fuller. But in cases where rough approximations

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* *Vide* paper read 10th September, 1885. Two of these instruments have been in constant use in the office of the Government Statist for a long time past, and have proved most invaluable for statistical computations.

are required by architects, engineers, surveyors, analytical chemists, actuaries and statisticians, mechanics, mathematicians, students and others, the circular rule now exhibited will doubtless prove of valuable assistance.

A considerable amount of time and labour is constantly being wasted in the present day, by making long calculations out of all proportion to the accuracy of the data involved. Take surveyors' calculations for example. A good ordinary —say a 6-inch—theodolite is divided to twenty minutes of a degree (20′), in which case the lines would be only about $\frac{1}{60}$th of an inch apart. It is quite within the bounds of possibility, therefore, that a rough observation might be liable to an error of 10′, which would be equivalent to an error in the sine, varying (in the case of angles under 70°) from ·001 to ·003, according to the magnitude of the angle. The error would be thus in the third place, and what can be the use of employing tables of sines calculated to six or seven places when the observation is, in the case supposed, not correct to even three. By means of the vernier, in like manner the same instrument may, by careful observation, be read to say within one minute of a degree (1′); then the error in the sine of the angle would vary from ·0001 to ·0003, which involves an error in the fourth place, and so on, according to the accuracy of the observation, and the precision of the particular instrument used.

I think it may be laid down as a general rule in arithmetical operations that a computer is justified in accepting as correct only as many figures (digits) in the product or the quotient, as there are reliable figures in either of the factors, or in either the divisor or dividend, by which such product or quotient respectively was obtained. For example, supposing it was required to find a death-rate at a particular age, *i.e.*, deaths divided by population, assuming the deaths to be fairly correct, and the population to be uncertain beyond (say) the third figure, any death-rate based on such figures would be incorrect beyond the third figure. It is the same in the case of products, the number of reliable figures in the result being solely dependent on the number of reliable figures in the most uncertain of its factors.

In using logarithms, likewise, a similar general rule might be applied, *i.e.*, to use logarithms to as many places only* as

* In special cases one place more might be used, so as to ensure of the last figure but one being as accurate as possible.

correspond to the number of correct digits in the numerical data involved. For example, it would be useless labour to use the log. sines of angles observed with an error of one minute of a degree to six or seven figures of decimals, when a table of four figure logarithms would answer equally well.

When these things are well understood and appreciated, the more extended tables of logarithms will be used less and less, and slide-rules will come into more general use.

For results to the second and third figure, the small circular slide-rule is best adapted; and for results to the fourth figure, the spiral slide rule is most invaluable; but for results beyond the fourth, we must still resort to mathematical tables or the arithmometre.

The great advantage of slide-rules over logarithmic tables are obvious. To find a product by logarithms, no less than seven operations* are necessary, and then there is the liability to error as well as loss of time in transcribing the logarithms, after finding the differences, and in adding them. With the slide-rule, only the natural numbers are dealt with, and it is merely necessary to bring the indices to the factors and the results may read off immediately by inspection.

I should mention, that I described in my paper on Fuller's Calculating Slide Rule, a circular rule somewhat similar to the calculimetre, called the *Cercle à calcul.*† The cercle à calcul more nearly resembles a watch, the calculations being performed by two hands—the one movable, and the other fixed. The cercle à calcul is in some respects the better instrument, but it is about three times the cost of the other, which is only about ten or twelve francs.

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* Multiplying $a \times b$; (1) find a in log. book; (2) then log. a and transcribe; (3) find b; (4) then log. b and transcribe; (5) find sum; (6) find same in log. book; and (7) find colog. a b.

† A similar instrument made in England is known by the name of "Boucher's Pocket Calculator."